

WHAT IS CLAIMED IS:

1. An optical fiber comprising:

an optical fiber which has a taper form shaped
elliptical in the cross section of one end face of a
core and cladding and changed gradually to be circular
as separating away from the end face;

a holding member which holds the optical fiber in
the predetermined length from the end face or the whole
body from the side of the optical fiber, and has a
coefficient of thermal expansion approximately equal to
the value of a coefficient of thermal expansion of the
cladding material of the optical fiber; and

a sealing material which fills a gap between the
optical fiber and the holding member.

2. A optical fiber module according to claim 1,
wherein at least one of the end faces of the optical
fiber is polished together with the holding member.

3. A optical fiber module according to claim 1,
wherein the holding member is glass or ceramic
material.

4. A optical fiber module according to any one of
claim 1 to 3, wherein the sealing material is glass
having a fusing point sufficiently lower than a glass
transition temperature of a core material and a glass
transition temperature of a cladding material of the
optical fiber.

5. A method of manufacturing an optical fiber

module comprising:

5 a first step of placing an optical fiber between substrates having a coefficient of thermal expansion approximately equal to a coefficient of thermal expansion of a cladding material of the optical fiber;

10 a second step of heating the substrates and the optical fiber placed between the substrates to a temperature higher than a glass transition temperature of a core material and a glass transition temperature of a cladding material of the optical fiber;

a third step of applying a predetermined pressure in the direction almost vertical to the bonded surface of the glass substrates while maintaining the temperature;

15 a fourth step of filling adhesive material in a gap between the optical fiber and the holding member, and bonding them; and

20 a fifth step of polishing the end face of the optical fiber together with the substrates holding the optical fiber.

6. A method of manufacturing an optical fiber module comprising:

25 a first step comprising a step of placing an optical fiber between substrates having a coefficient of thermal expansion approximately equal to a coefficient of thermal expansion of a cladding material of the optical fiber, and a step of inserting a spacer

member having a predetermined thickness in at least one location between the substrates;

5 a second step of heating the substrates, the optical fiber placed between the substrates, and the spacer member to a temperature higher than a glass transition temperature of a core material and a glass transition temperature of a cladding material of the optical fiber;

10 a third step of applying a predetermined pressure in the direction almost vertical to the bonded surface of the glass substrates while maintaining the temperature;

15 a fourth step of filling adhesive material in a gap between the optical fiber and the holding member, and bonding them; and

a fifth step of polishing the end face of the optical fiber together with the substrates holding the optical fiber.

20 7. A method of manufacturing an optical fiber module comprising:

25 a first step comprising a step of inserting an optical fiber between substrates having a coefficient of thermal expansion approximately equal to a coefficient of thermal expansion of a cladding material of the optical fiber, and a step of inserting between the substrates a predetermined amount of a low fusing point glass material having a fusing point sufficiently

lower than a glass transition temperature of a core material and a glass transition temperature of a cladding material of the optical fiber;

5 a second step of heating the substrates, the optical fiber inserted between the substrates, and the low fusing point glass material to a temperature higher than a glass transition temperature of a core material and a glass transition temperature of a cladding material of the optical fiber;

10 a third step of applying a predetermined pressure in the direction almost vertical to the bonded surface of the glass substrates while maintaining the temperature; and

15 a fourth step of polishing the end face of the optical fiber together with the substrates holding the optical fiber.

8. A method of manufacturing an optical fiber module comprising:

20 a first step comprising a step of inserting an optical fiber between substrates having a coefficient of thermal expansion approximately equal to a coefficient of thermal expansion of a cladding material of the optical fiber, a step of inserting a spacer member having a predetermined thickness in at least one
25 location between the substrates, and a step of inserting between the substrates a predetermined amount of a low fusing point glass material having a fusing

point sufficiently lower than a glass transition temperature of a core material and a glass transition temperature of a cladding material of the optical fiber;

5 a second step of heating the substrates, the optical fiber placed between the substrates, the spacer member, and the low fusing point glass material to a temperature higher than a glass transition temperature of a core material and a glass transition temperature
10 of a cladding material of the optical fiber;

 a third step of applying a predetermined pressure in the direction almost vertical to the bonded surface of the glass substrates while maintaining the temperature; and

15 a fourth step of polishing the end face of the optical fiber together with the substrates holding the optical fiber.

9. An image display unit comprising:

 fiber laser apparatuses which output R, G and B
20 lights;

 spatial modulation elements which spatially modulate the R, G and B lights;

 a synthesizing means which synthesizes the R, G and B lights spatially modulated by the spatial
25 modulation elements; and

 an optical element which forms the image of the output light of the synthesizing means at

a predetermined position;

wherein at least one of the fiber laser
apparatuses has an optical fiber module manufactured by
the method of claim 5, between a semiconductor laser
5 and an up-conversion fiber.

10. An image display unit comprising:

fiber laser apparatuses which output R, G and B
lights;

a white light synthesizing means which collects
10 the R, G and B lights as one light and makes it a white
light when viewed macroscopically;

a spatial modulation element which spatially
modulates the output light of the white light
synthesizing means; and

15 an optical element which forms the image of the
light modulated spatially by the spatial modulation
element at a predetermined position;

wherein at least one of the fiber laser apparatus
has an optical fiber module manufactured by the method
20 of claim 5, between a semiconductor laser and an up-
conversion fiber.

11. An image display unit comprising:

fiber laser apparatuses which output R, G and B
lights;

25 spatial modulation elements which spatially
modulate the R, G and B lights;

a synthesizing means which synthesizes the R, G

and B lights spatially modulated by the spatial modulation elements; and

an optical element which forms the image of the output light of the synthesizing means at a
5 predetermined position;

wherein at least one of the fiber laser apparatuses has an optical fiber module manufactured by the method of claim 6, between a semiconductor laser and an up-conversion fiber.

10 12. An image display unit comprising:

fiber laser apparatuses which output R, G and B lights;

a white light synthesizing means which collects the R, G and B lights as one light and makes it a white
15 light when viewed macroscopically;

a spatial modulation element which spatially modulates the output light of the white light synthesizing means; and

an optical element which forms the image of the
20 light modulated spatially by the spatial modulation element at a predetermined position;

wherein at least one of the fiber laser apparatus has an optical fiber module manufactured by the method of claim 6, between a semiconductor laser and
25 an up-conversion fiber.

13. An image display unit comprising:

fiber laser apparatuses which output R, G and B

lights;

spatial modulation elements which spatially modulate the R, G and B lights;

5 a synthesizing means which synthesizes the R, G and B lights spatially modulated by the spatial modulation elements; and

an optical element which forms the image of the output light of the synthesizing means at a predetermined position;

10 wherein at least one of the fiber laser apparatus has an optical fiber module manufactured by the method of claim 7, between a semiconductor laser and an up-conversion fiber.

14. An image display unit comprising:

15 fiber laser apparatuses which output R, G and B lights;

a white light synthesizing means which collects the R, G and B lights as one light and makes it a white light when viewed macroscopically;

20 a spatial modulation element which spatially modulates the output light of the white light synthesizing means; and

an optical element which forms the image of the light modulated spatially by the spatial modulation element at a predetermined position;

25 wherein at least one of the fiber laser apparatuses has an optical fiber module manufactured by

the method of claim 7, between a semiconductor laser and an up-conversion fiber.

15. An image display unit comprising:

5 fiber laser apparatuses which output R, G and B lights;

spatial modulation elements which spatially modulate the R, G and B lights;

a synthesizing means which synthesizes the R, G and B lights spatially modulated by the spatial modulation elements; and

10 an optical element which forms the image of the output light of the synthesizing means at a predetermined position,

wherein at least one of the fiber laser apparatuses has an optical fiber module manufactured by the method of claim 8, between a semiconductor laser and an up-conversion fiber.

16. An image display unit comprising:

20 fiber laser apparatuses which output R, G and B lights;

a white light synthesizing means which collects the R, G and B lights as one light and makes it a white light when viewed macroscopically;

25 a spatial modulation element which spatially modulates the output light of the white light synthesizing means; and

an optical element which forms the image of

the light modulated spatially by the spatial modulation element at a predetermined position;

wherein at least one of the fiber laser apparatuses has an optical fiber module manufactured by the method of claim 8, between a semiconductor laser
5 and an up-conversion fiber.